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Temporal changes in the abundance of *Musca domestica* Linn (Diptera: Muscidae) in poultry farms in Penang, Malaysia

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Abstract: Changes in the abundance of the house fly, *Musca domestica*, was studied for a period of one year in two poultry farms in Penang, Malaysia: one in Balik Pulau, located in Penang island, and the other in Juru, located on mainland Penang. The sampling of house flies were carried out from March 2007 to April 2008 using the Scudder grill, and the correlation with meteorological conditions particularly rainfall, relative humidity and temperature were observed. In Balik Pulau, the fly abundance showed an inverse relationship to relative humidity and total rainfall. However, no significant correlations were found between the abundance of flies and the above mentioned climatic factors. In contrast, the occurrence of flies in Juru showed strong correlation indices with relative humidity ($r = 0.803$, $p < 0.05$) and total rainfall ($r = 0.731$, $p < 0.05$). Temperature had no significant effect on the abundance of flies in both poultry farms due to imperceptible changes in monthly temperature.

INTRODUCTION

Housefly, *Musca domestica*, is a cosmopolitan synanthropic insect of medical and veterinary importance (Greenberg, 1971), which is capable of transmitting infectious organisms mechanically. It is a major pest in animal production facilities, especially poultry farms (West, 1951; Axtell, 1985; Williams *et al.*, 1985), resulting in annoyance and indirect damage in livestock production.

The number of houseflies varies in a given locality, depending on climatic factors (WHO, 1981) and duration of daytime (WHO, 1986). Both influence the rate of mating, the preoviposition period, oviposition and feeding of adults. In temperate regions, housefly density starts increasing in spring and reaches its peak during the 3-8 month summer season and then decreases in autumn. Freezing conditions during winter may preclude all possibility of species survival. According to Hewitt (1915) and Somme (1961), adult houseflies are the important overwintering stage. They overwinter in part by continuously breeding in suitable places, or as hibernating females. This contributes to the high density of houseflies in the next spring and summer. However, Skinner (1913) observed that pupae appear to tolerate lower temperatures.

In tropical and subtropical areas, housefly abundance may decline during the hottest months (Madwar & Zahar, 1953; WHO, 1986). However, the flies are active all year round in tropical rainforest countries. Breeding of flies in the tropics rarely terminates completely as a result of seasonal change. In unfavorable conditions, a mere reduction in the intensity of reproductive activity results in a reduction of the population. With the return of favorable conditions, flies increase in numbers, and may reach a seasonal peak.

Apart from that, fly abundance is also found to be associated with poor sanitation where manure is abundant (Hughes & Walker, 1969). Livestock manure that is constantly being changed by numerous abiotic and biotic factors, affects the population of house flies. The foul-smelling manure gives off by-products like ammonia and carbon dioxide which attracts a large number of flies to breed in the moist manure. Concentrated organic manures, used in vegetable gardens are also principal breeding places for house flies (Pagden & Reid, 1952).

The use of insecticide to reduce housefly population has resulted in resistance development. Hence, the development of new technologies for control has raised the interests to investigate fly abundance over an extended period of time as the information might suggest a particularly advantageous period to control flies. To date, limited information on the seasonal abundance of flies in Malaysia is available.

MATERIALS AND METHODS

Site selection

The 14-month study was conducted from March 2007 to April 2008 in two poultry farms: Balik Pulau and Juru which are 21.68km apart.

Balik Pulau, a suburban area on the island of Penang, is famous for its fruit orchards and spice gardens. It is located approximately 8km (altitude 2.8m) from the capital city, Georgetown. The egg-production poultry farm consists of one narrow-style (4.32m by 23.87m) poultry shed, with two rows of three-tiered cages (91 cages per tier with 2-3 birds per cage) suspended 0.80m above the ground. Removal of chicken manure is sporadic with manure accumulating on the ground. A durian plantation is situated a kilometer away from the poultry farm.

Juru is one of the industrial corridors in the northern region of peninsular Malaysia which has led to rapid housing development. The meat-production poultry farm which is located in Juru is approximately 15km (altitude 15.0m) from Georgetown. It is approximately 4.66km away from the housing and industrial areas, and situated in an oil palm plantation. The farm consists of four wide-span (6.50m by 75.00m) poultry sheds with approximately 4000-5000 birds per shed. The sheds are suspended one meter above the ground. Manure is removed regularly before a new batch of chickens is released into the poultry sheds. Fly sampling in Juru was conducted every two months when the chickens are 25-28 days old.

Scudder grill

In this study, Scudder grill (Scudder, 1947) has been used for sampling the fly population. The Scudder grill has been used in many studies as the standard device for measurement of fly populations in many control programs throughout the world because it neither repels nor actively attracts the flies (Holway *et al.*, 1951; Ricciardi & Paulini, 1955; Dhillon & Challet, 1985; Nazni *et al.*, 2003b)

The method of sampling was as recommended by WHO (1991). The flies that land on the grill within 30 seconds are counted; 4 to 6 counts were made in each locality, and the arithmetic means of these counts are recorded as the fly index. Fly survey was conducted monthly in the morning from 0900 to 1100 as standard time (Sulaiman *et al.*, 1999) when housefly was found active.

Meteorological data

Precipitation data from March 2007 to April 2008 was obtained from the Malaysian Meteorological Department (MMD), Bayan Lepas and Prai station, Penang, Malaysia. Temperature and relative humidity were observed using a hygro-thermometer (Ters Electronic Ltd., China).

Statistical analysis

The number of fly counts was subjected to a one-way analysis of variance (SPSS analysis version 11.0) to determine the significant differences in density of fly between months. Pearson correlation test (SPSS analysis version 11.0) was also used to evaluate the relationship between the abundance and environmental factors. The tests were performed using a significance level of α = 0.05. A three-dimensional plot of climatic factors and density was generated using SigmaPlot (SPSS 2002) software. Raw data were smoothed and fitted to a plane function of the form: density of fly = aX + bY + c; X= total rainfall, Y= temperature.

RESULTS AND DISCUSSION

The fly density in the Balik Pulau poultry farm was homogenous with no significant differences throughout the year, exhibiting a range of 29.40 ± 3.49 to 51.00 ± 11.51 flies (Figure 1). The population was high and constant from March 2007 to July 2007 ranging from 43.60 ± 7.54 to 49.33 ± 17.71 flies. The population started to fall in August 2007 with 29.75 ± 2.43 flies and remained low for two consecutive months. During the months of November 2007 to February 2008, the flies increased in numbers, recording a peak of 51.00 ± 11.51 flies in February 2008. The density of flies then declined to 29.40 ± 3.49 flies in March 2008 and 32.40 ± 3.56 flies in April 2008.

Temperature had no significant effect on the abundance of flies in the Balik Pulau poultry farm due to imperceptible changes in the monthly temperature, ranging from 28.6 ºC to 34.4 ºC (Figure 1). The occurrence of flies in relation to relative humidity and total rainfall was shown to have an inverse relationship (Figure 1 and Figure 2). However, no significant correlations were found between the density of flies and the above mentioned climatic factors ($p > 0.05$) (Table 1). Substantial rainfall in the months of September 2007 (480.2 mm), October 2007 (300.0 mm), March 2008 (221.6 mm) and April 2008 (246.0 mm) showed a reduction in the fly population. The highest population of flies was recorded in February 2008, a period of least rainfall (44.2 mm). Heavy rain may cause excessive wetness to the manure, making it an unsuitable breeding site for flies. The third instar larvae, which prefer drier habitat was unable to turn into pupae. A study carried out by Bruce (1939) showed that pupae placed in jars of fine sand emerged to become adult flies when the sand had a water content ranging from 0% to 14%, but rarely any higher.

The fly density in Juru was found to be distributed heterogeneously, $F (6, 39) = 7.988$, $p < 0.05$, ranging from 12.00 ± 1.50 to 41.17 ± 6.52 flies (Figure 3). The population was high from March 2007 to September 2007, ranging from 21.67 ± 2.79 to 35.4 ± 4.38 flies. The lowest population was recorded in November 2007 (12.00 ± 1.50 flies) and January 2008 (18.14 ± 2.19 flies), and considered at a good sanitary level. The population peaked in the month of March 2008 with 41.17 ± 6.52 flies.

Apparently, the Juru poultry farm practiced better sanitation by regularly removing the chicken manure compared to the Balik Pulau poultry farm. This practice was almost impossible in the Balik Pulau poultry farm due to the continuous rearing of chickens, contributing to a very high count and a homogenous fly density throughout the year. Poor sanitation is related to the availability of food and breeding sites, resulting in a diversity of the existing seasonal patterns in the tropics (Quarterman *et al.*, 1954a; 1954b; Morris & Hansen, 1966; Oda, 1966; Picken *et al.*, 1967; Wolda, 1988).

The density of flies in Juru increased when high temperatures were recorded (Figure 3). Nevertheless, there was no significant correlation between the density of flies and temperature (Table 1). Surprisingly, the occurrence of flies showed strong correlation indices with relative humidity ($r = 0.803$, $p < 0.05$) and total rainfall ($r = 0.731$, $p < 0.05$), contradicting what was observed in Balik Pulau. Figure 4 shows that high fly density correlated with heavy rainfall which was obvious in the month of March 2008 with a total rainfall of 363.0 mm. Marked

Table 1. Pearson correlation (r) for fly population in relation to environmental factors (relative humidity, temperature, and total rainfall)

Environmental factors	Density of flies Balik Pulau (N=14)	Juru (N=7)
Relative humidity	-0.408	0.803*
Temperature	0.175	-0.255
Total rainfall	-0.183	0.731*

* Correlation is significant at the 0.05 level

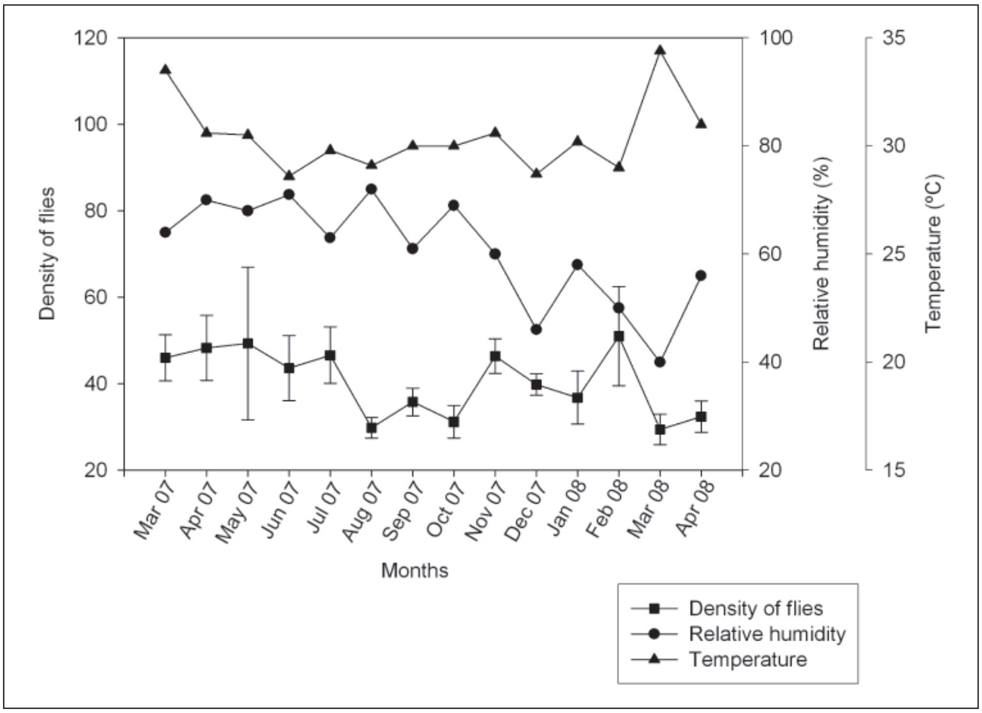

Figure 1. Temporal changes of fly populations in Balik Pulau in relation to relative humidity and temperature.

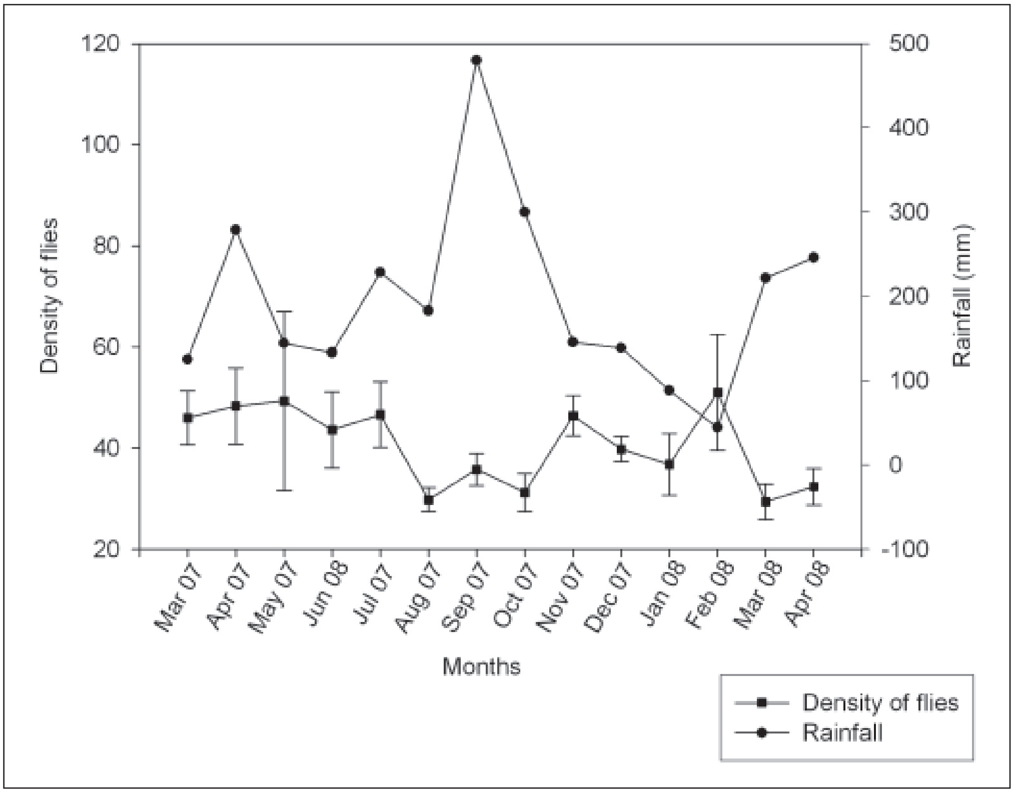

Figure 2. Temporal changes of fly populations in Balik Pulau in relation to rainfall.

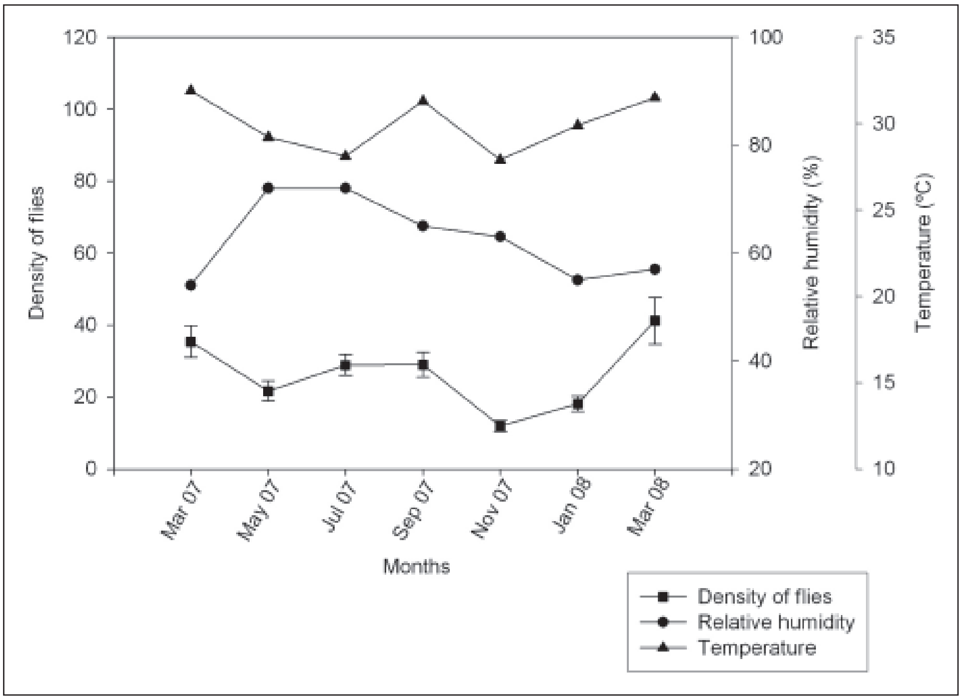

Figure 3. Temporal changes of fly populations in Juru in relation to relative humidity and temperature.

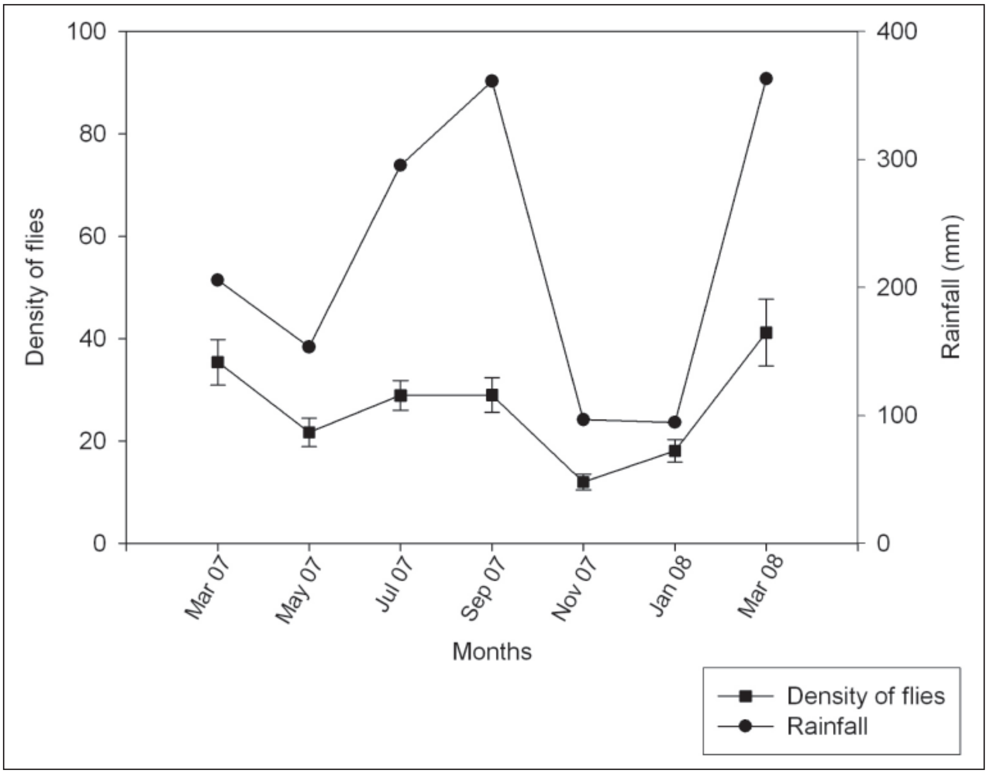

Figure 4. Temporal changes of fly populations in Juru in relation to relative rainfall.

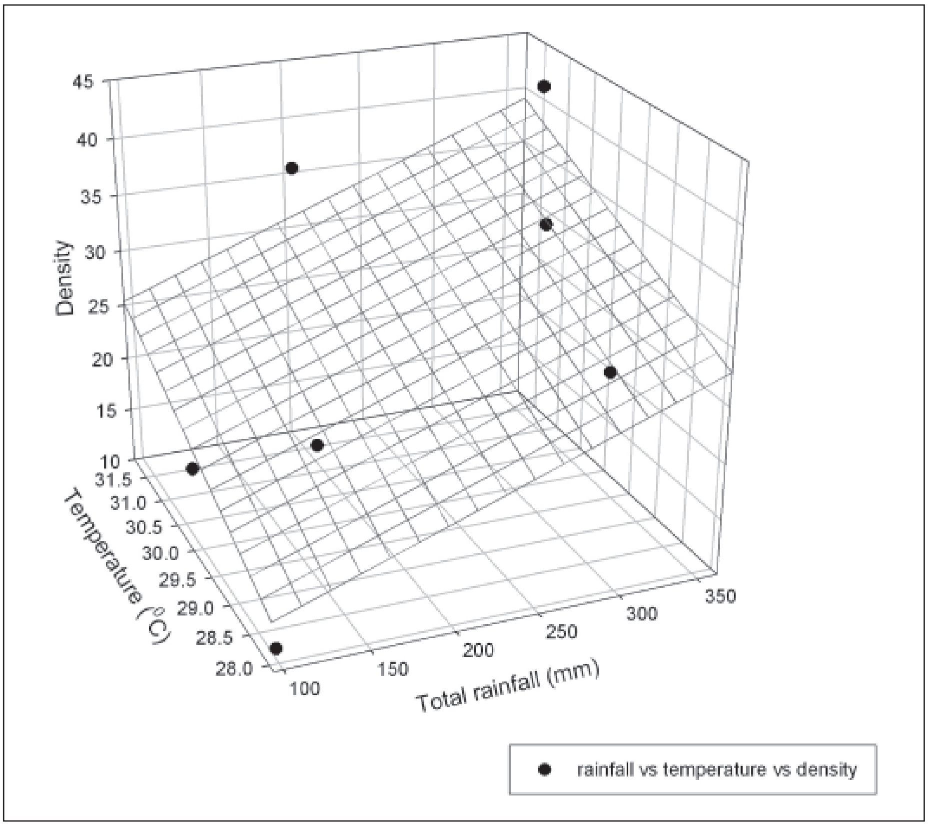

Figure 5. Scatter plot of Juru fly density in relation to temperature and total rainfall.

decreases in fly density were observed in November 2007 and January 2008 when total rainfall was less at 96.8mm and 94.6mm respectively. The low volume of rainfall caused excessive dryness of the manure, eliminating the larvae from the breeding site.

Fly density in tropical and subtropical areas may decline during the hottest months (Madwar & Zahar, 1953; WHO, 1986). However, the population may increase in hot and rainy weather, as shown in Juru (Figure 5). The equation relating Juru fly density to temperature and total rainfall is as follow: density of fly = (0.05 ± 0.02) total rainfall + (2.76 ± 1.57) temperature + (-67.38 ± 44.85); $r^2 = 0.800$; Standard Error of Estimation = 5.533; $F = 7.981$; $p < 0.05$.

Although the fly density in Balik Pulau poultry farm was homogenous throughout the year, the fly density still showed a slight reduction during the rainy season but was the opposite in Juru. Results documented have shown that fly season can be different between localities and environment (Mullens & Meyer, 1987; Greene, 1989; Lysyk, 1993), although climatic factors are related with the seasonal fluctuations of flies.

Nazni *et al.* (2003a) reported that in Malaysia, heavy rainfall was found to influence the high density of flies in poultry farm in lowland whereas temperature indicated a strong relationship with the fly density in vegetable farm in highland.

In the inland tropics of Australia, *Musca vetustissima*, the Australian bushfly, was low in numbers during the heavy summer rainfall but increased to peak numbers in the autumn and decreased throughout the winter. However, the flies in the southern areas of Australia increased to peak numbers in the summer (Norris, 1966).

Singh (1971) reported that relative humidity was the only significant factor and that none of the other climatic factors had any significant effect on the abundance of *M. domestica* in Kuala Lumpur, Malaysia.

Studies on the influence of climatic factors on the populations of *Stomoxys calcitrans* in dairy farms in Aguascalientes State, Mexico, a semiarid region, indicated that relative humidity showed significant correlations ($r = 0.6$ to 0.8, $p < 0.01$) with the fluctuations within population-increasing phase during the spring-summer period (Cruz-vazquez *et al.*, 2004). This was because the adult flies began to emerge from overwintering pupae and underwent a rapid growth when high relative humidity was recorded (Lysyk, 1993; Greene & Guo, 1997). However, the population-decreasing phase in the fall was remarkably correlated with temperature ($r = 0.9$, $p < 0.01$) (Cruz-vazquez *et al.*, 2004).

In contrast to the tropics, temperature is the main climatic factor that influences the seasonal changes of the fly population in temperate countries. LaBrecque *et al.* (1972) noted that the density of *M. domestica* and *S. calcitrans* in the livestock farms from north central Florida changed gradually and remarkably by increasing in the spring-summer period when mean temperatures ranged from 25.5ºC to 27.2ºC, and decreasing in the fall and winter when temperature ranged from 9.5ºC to 14.8ºC.

The occurrence of *M. domestica* was seen throughout the year in the vicinity of Cairo, being notably abundant in the spring, when atmospheric temperatures ranged from 28ºC to 35ºC (Hafez, 1941).The temperatures in the spring-summer period were optimal for flies to breed, resulting in the high density of flies during the warmer months. Cool temperatures have deleterious effects on the development of immature stages, adult emergence as well as adult activity.

From the present study, flies are abundant and active when warm temperatures were recorded, ranging from 25.0ºC to 35.0ºC. This explains why flies are active all year round in the tropics especially in poultry farms where their food source, chicken manure, is abundant. Temperature is not the main climatic factor influencing the fluctuations of the fly populations in Balik Pulau and Juru due to its imperceptible changes throughout the year, ranging from 27.9ºC to 34.4ºC. However, seasonal abundance of flies in the two sites is influenced by the changes in total rainfall and relative humidity.

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REFERENCES

Axtell, R.C. (1985). Fly management in poultry production: cultural, biological, and chemical. *Poultry Science* **65:** 657-667.

Bruce, W.G. (1939). Some observations on insect edaphology. *Journal of the Kansas Entomology Society* **12:** 91-93.

Cruz-vazquez, C., Mendoza, I.V., Parra, M.R. & Garcia-vazquez, Z. (2004). Influence of temperature, humidity and rainfall on field population trend of *Stomoxys calcitrans* (Diptera: Muscidae) in a semiarid climate in Mexico. *Parasitologia latinoamericana* **59:** 99-103.

Dhillon, M.S. & Challet, G.L. (1985). The evaluation of three sampling techniques for the determination of fly (Diptera) densities at four sanitary landfills in southern California. *Bulletin of the Society of Vector Ecology* **10:** 36-40.

Greenberg, J.B. (1971). *Flies and disease: Ecology, classification and biotic associations*. Princeton University Press, New Jersey.

Greene, G.L. (1989). Seasonal population trends of adult stable flies. Miscellaneous Publication 74., Lanham.

Greene, G.L. & Guo, Y.J. (1997). Integrated stable fly (*Stomoxys calcitrans*) management in confined cattle feedlots. *Recent Research Developments in Entomology* **1:** 243-250.

Hafez, M. (1941). A study of the biology of the Egyptian common house-fly: *Musca vicina* Macq. (Diptera: Muscidae). *Bulletin de la Société Fouad Ler D´Entomologie* **25:** 163-189.

Hewitt, C.G. (1915). Notes on the pupation of the house-fly (*Musca domestica*) and its mode of overwintering. *The Canadian Entomologist* **47:** 73-78.

Holway, R.T., Mitchell, W.A. & Sal-ah, A.A. (1951). Studies on the seasonal prevalence and dispersal of the Egyptian house fly (*Musca domestica*). I. The adualt flies. *Annals of the Entomological Society of America* **44:** 381-398.

Hughes, R.D. & Walker, J. (1969). The role of food in the population dynamics of the Australian bushfly. In: *Animal populations in relation to their food resources* (Editor, A. Watson) pp. 255-269. Oxford and Edinburgh.

LaBrecque, G.C., Meifert, D.W. & Weidhaas, D.E. (1972). Dynamics of house fly and stable fly populations. *The Florida Entomologist* **55:** 101-106.

Lysyk, T.J. (1993). Seasonal abundance of stable flies and house flies (Diptera: Muscidae) in dairies in Alberta, Canada. *Journal of Medical Entomology* **30:** 888-895.

Madwar, S. & Zahar, A.R. (1953). Some ecological observations on houseflies in Egypt. *Bulletin of the World Health Organization* **8:** 513-519.

Morris, A.P. & Hansen, E.J. (1966). Dispersion of insecticide resistant populations of the house fly, *Musca domestica* L. *Journal of Economic Entomology* **59:** 45-50.

Mullens, B.A. & Meyer, J.A. (1987). Seasonal abundance of stable flies (Diptera: Muscidae) on California dairies. *Journal of Economic Entomology* **80:** 1039-1043.

Nazni, W.A., Lee, H.L., Sadiyah, I. & Sofian, M.A. (2003a). Monthly prevalence of house fly, *Musca domestica* in lowlands and highlands and its association with chemical resistance. *Tropical Biomedicine* **20:** 65-76.

Nazni, W.A., Lee, H.L., Sofian, M.A. & Sadiyah, I. (2003b). Guidelines for fly control. *Tropical Biomedicine* **20:** 59-63.

Norris, K.R. (1966). Notes on the ecology of the bushfly, *Musca vetustissima* Walker (Dipter, Muscidae), in the Canberra district. *Australian Journal of Zoology* **14:** 1139-1156.

Oda, T. (1966). Studies on the dispersal of the house fly *Musca domestica vicina* by mark and release method. *Bulletin of Endemic Diseases* **8:** 136-144.

Pagden, H.T. & Reid, J.A. (1952). Flies at Cameron Highlands. Cyclostyled report, Kuala Lumpur.

Picken, L.G., Morgan, N.O., Hartstock, J.G. & Smith, J.W. (1967). Dispersal patterns and populations of the house fly affected by sanitation and weather in rural Maryland. *Journal of Economic Entomology* **60:** 1250-1255.

Quarterman, K.D., Mathis, W. & Kilpatrick, J.W. (1954a). Fly dispersal in a rural area near Savannah, Georgia. *Journal of Economic Entomology* **47:** 413-419.

Quarterman, K.D., Mathis, W. & Kilpatrick, J.W. (1954b). Urban fly dispersal in the area of Savannah, Georgia. *Journal of Economic Entomology* **47:** 405-412.

Ricciardi, J. & Paulini, E. (1955). Normas gerais para determina ao da densidade de *Musca domestica* em umqa localidade. *Revista Brasileira de Malariologia e Doenças Tropicai* **7:** 93-101.

Scudder, H.I. (1947). A new technique for sampling the density of housefly populations. *Public Health Reports* **62:** 681-686.

Singh, K.I. (1971). Prevalence of the house fly *Musca domestica* (L.) in the vicinity of Kuala Lumpur. *Southeast Asian Journal of Tropical Medicine and Public Health* **2:** 548-551.

Skinner, H. (1913). How does the house-fly pass the winter? *Entomology News* **24:** 303-304.

Somme, L. (1961). On the ovewintering of house-flies (*Musca domestica*) and stable flies (*Stomoxys calcitrans*) in Norway. *Norsk Entomologiskl Tidsskrift* **11:** 191-223.

Sulaiman, S., Othman, M.Z., & Aziz, A.H. (1999). Isolations of enteric pathogens from synanthropic flies trapped in downtown Kuala Lumpur. *Journal of Vector Ecology* **25:** 90-93.

Williams, R.E., Hall, R.D., Broce, A.B. & Scholl, P.J. (1985). Livestock entomology. Wiley, New York.

WHO. (1981). Instructions for determining the susceptibility or resistance of house flies, tsetse, stable flies, blow flies, etc. to insecticides. Document WHO/VBC/81.813. World Health Organization, Geneva.

WHO. (1986). The housefly. Document WHO/VBC/86.937. World Health Organization, Geneva.

WHO. (1991). The housefly. WHO/VBC/90.987. World Health Organization, Geneva.

Wolda, H. (1988). Seasonality and the community. In: *Organization of communities* (Editors, J. H. R. Gee & P. S. Giller) pp. 69-95 Blackwell, Oxford.